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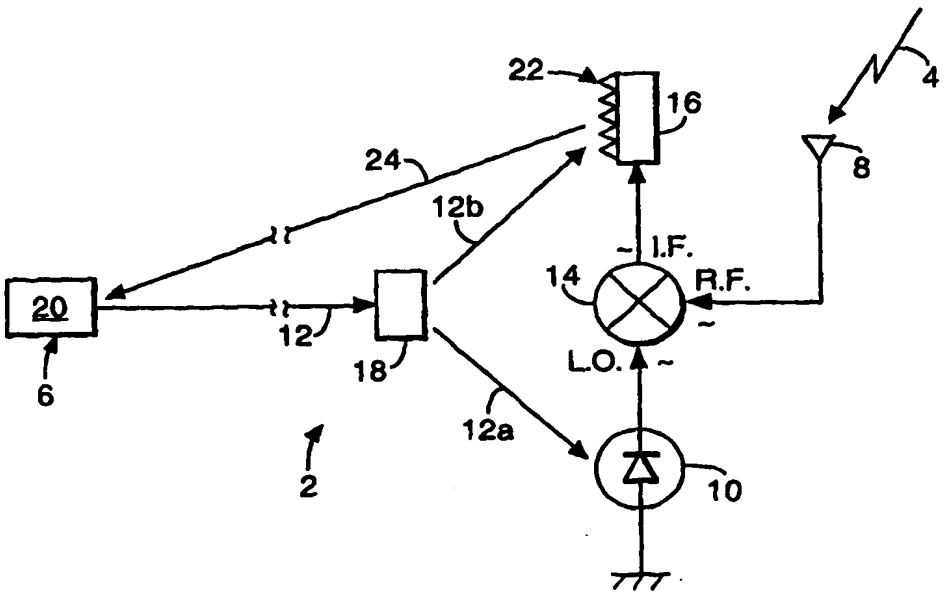

(57) Abstract

A radio frequency (RF) receiver circuit (2) comprises: an antenna (8) for receiving a radio frequency (RF) signal (4); an optical detector (10) for receiving a modulated optical signal (12) and converting it to an electrical signal; means (14) for mixing the electrical and RF signals to produce an intermediate frequency signal; and a reflective optical modulator (16) which is operable at the intermediate frequency to modify and reflect (24) the modulated optical signal (12) with the intermediate frequency. By detecting the optical signal which has been modified by the circuit, it is possible to remotely detect the RF signal received by the circuit and the circuit thus acts as a remotely accessible RF receiver circuit.

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RADIO FREQUENCY RECEIVER CIRCUIT

This invention relates to a radio frequency (RF) receiver circuit and more especially, although not exclusively, to a remotely accessible and tuneable radio receiver circuit for use as a radio relay.

According to the present invention a radio frequency receiver circuit is characterised by comprising: an antenna for receiving a radio frequency signal; an optical detector for receiving a modulated optical signal and converting it to an electrical signal; means for mixing the electrical and radio frequency signals to produce an intermediate frequency signal; and a reflective optical modulator which is operable at the intermediate frequency to modify and reflect the optical signal with the intermediate frequency signal.

By detecting the optical signal which has been modified and reflected by the circuit, it is possible to remotely detect the radio frequency (RF) signal received by the circuit and the circuit thus acts as a remotely accessible RF receiver. Furthermore, since the modulation frequency of the illuminating optical signal determines the local oscillator frequency of the circuit, the circuit further operates as a remotely tuneable RF receiver. The term radio frequency is intended to have a broad meaning to include any electromagnetic radiation which is propagating in free space and is intended to include such radiation in at least the frequency range 10 kHz to 300GHz. A particular advantage of the receiver circuit of the present invention is that due to its simplicity it is inexpensive and yet provides a high performance capability. Depending on the performance required the circuit can either include its own power source such as a battery or it can rely on the

optical signal to provide the electrical energy required to operate it. Since the local oscillator frequency of the circuit is set by the modulation frequency of the optical signal, the circuit does not need to generate its own stable reference frequency and this reduces the circuit's complexity and electrical power consumption.

Preferably the means for mixing the modulated electrical and RF signals comprises a non-linear radio frequency component such as a transistor and the optical receiver comprises a photodiode. In a particularly preferred form the photodiode is used as both the non-linear component and the optical receiver and the circuit is illuminated with a high intensity optical signal such that the photodiode operates as a non-linear device.

In one arrangement the circuit further comprises means, such as, for example, an optical beam splitter, for directing a part of the optical signal onto the optical detector and a part onto the reflective optical modulator. Advantageously in an alternative arrangement the optical receiver is located on the reflective surface of the optical modulator such that the optical signal is simultaneously incident on the reflective optical modulator and optical detector thereby eliminating the need for an optical beam splitter.

In yet a further implementation of the invention the circuit further comprises means such that the circuit transmits a radio frequency signal from the antenna and wherein the frequency of said transmitted signal is related to the modulation frequency of the optical signal used to illuminate the circuit. In a preferred embodiment the circuit is capable of simultaneously transmitting and receiving a receiver radio frequency signal. Such a circuit is ideally suited as an interrogator circuit for use in a tagging system which uses

tags containing semi-passive (sometimes termed pseudo passive) transponder circuits since it is capable of illuminating a semi-passive tag with an RF signal and is capable of simultaneously detecting any modulation applied to this signal by the tag. A particular advantage of such an interrogator circuit is that communication over large distances is possible using only low power radio transmitters as the circuit is optically remotely accessible.

In a further preferred arrangement a photodiode is connected to the antenna such that the resonant frequency of the antenna can be remotely tuned using the optical signal to set the capacitance of the photodiode. Such an arrangement is particularly advantageous when the circuit is being operated as a transmitter circuit. It is envisaged either to provide a separate photodiode for this purpose or to use a single photodiode to both tune the antenna and detect the modulation of the optical signal. In the case of the former it is preferred to illuminate the circuit with two optical signals (i) a continuous wave optical signal for tuning the antenna and (ii) a modulated optical signal of a different wavelength to set the local oscillator frequency of the circuit. The concept of using an optical signal both to tune an antenna and to provide the local oscillator frequency for receiving and/or transmitting an RF signal in a radio frequency circuit is considered inventive in its own right.

In yet a further application of the invention, a radio receiver array comprises a plurality of radio frequency circuits as described above.

With any embodiment of the invention, the optical signal can propagate through free

space and thus the circuit operates as an essentially 'line of sight' device or can be guided using an optical fibre or other light guide. In the latter case and in accordance with a further application of the invention, a distributed antenna system comprises one or more optical fibres including a plurality of radio frequency receiver circuits described above, associated with the optical fibre/s. Such an arrangement finds particular application as part of a telecommunications system within a building as it enables cordless communication using low power radio devices.

According to a second aspect of the invention a radio frequency circuit is characterised by comprising an antenna and a photodiode connected across the antenna wherein the photodiode is operable to receive a modulated optical signal to provide the local oscillator frequency of the circuit and wherein the capacitance of the photodiode is used to tune the antenna.

In order that the invention may be better understood, five circuits in accordance with of the invention will now be described, by way of example only, with reference to the accompanying drawings in which:

Figure 1a is a schematic representation of a radio frequency receiver (relay) circuit in accordance with the invention;

Figure 1b is a schematic circuit diagram of the relay circuit of Figure 1a;

Figure 2 is a schematic of a further remotely accessible radio frequency relay circuit in

accordance with the invention;

Figure 3 is a schematic representation of a remotely accessible radio frequency relay circuit according to a further aspect of the invention in which the antenna can be remotely tuned;

Figure 4 is a schematic representation of a remotely accessible radio frequency relay circuit with a further form of remote antenna tuning; and

Figure 5 is a schematic representation of a circuit for use in a tagging system in accordance with the invention.

Referring to Figure 1a there is shown a radio relay circuit 2 which is capable of receiving and detecting a modulated radio frequency (RF) signal 4 in the frequency range 400 to 500 MHz and relaying the detected signal to a point 6 which is remote from the circuit 2. The relay circuit 2 comprises: an antenna 8 for receiving the modulated RF signal 4; a photodiode 10 which is capable of operating at radio frequencies for receiving and detecting a modulated optical signal 12; a non-linear mixer 14 for mixing the detected RF and optical signals; a piezoelectric resonator 16 and an optical beam splitter 18 for splitting the optical signal 12 to ensure that a respective part 12a, 12b of the signal is incident on the photodiode 10 and the resonator 16.

As shown in Figure 1b the non-linear RF component 14 can comprise a gallium arsenide (GaAs) field effect transistor (FET) which is configured by a matching circuit (not

shown), which can comprise lengths of transmission line or discrete lumped elements, to operate as an ultra low current mixer circuit for mixing the RF signal 4 received by the antenna 8 with the electrical signal produced by the photodiode 10 as a result of the modulated optical signal 12a.

In operation a laser vibrometer system 20 which is located at the remote point 6 illuminates the circuit 2 with a beam of infra red (IR) light (1500 nm) 12 which is amplitude modulated (AM) at a selected radio frequency. The modulation frequency is selected to be the required frequency of operation of the radio relay circuit 2 which, for the embodiment illustrated, is in the range 400 to 500 MHz.

The optical signal 12 is split by the optical beam splitter 18 such that a part 12a of this signal is incident on the photodiode 10 and a part 12b is incident on the surface of the piezoelectric resonator 16. Although the function of the piezoelectric resonator is described below, it is sufficient to state that it has a retro-reflective surface 22 which reflects light 24 back towards the laser vibrometer 20.

The light 12a which is incident on the photodiode 10 is converted into an electrical signal which is used (i) to provide electrical energy to the circuit 2 and (ii) to act as a local oscillator for the GaAs FET mixer 14 by injecting the modulation frequency of the optical signal 12 into the gate g of the FET 14. The radio frequency signal 4 which is received by the antenna 8 is mixed by the FET 14 to produce a low frequency product signal, or intermediate frequency (IF) signal, which is applied to the piezoelectric resonator 16. The IF signal which is representative of the frequency difference between the RF signal

4 and the local oscillator frequency causes the retro-reflective surface 22 of the piezoelectric resonator 16 to vibrate at this frequency. Vibration of the retro-reflective surface 22 modifies the phase and/or amplitude of the reflected optical signal 24 and this modification is detected by the laser vibrometer system 20.

It will be appreciated that the circuit 2 thus acts as a remotely accessible radio receiver, or relay, for detecting low power radio frequency signals and can be remotely tuned to a desired frequency of operation by the frequency of modulation of the illuminating optical signal 12. Since the optical signal 12 is used to provide energy to the circuit 2, the circuit does not need to include a battery and consequently has a very long operating life expectancy. Furthermore, due to the simplicity of the circuit, an extremely compact and inexpensive device can be produced which is preferably encapsulated in an IR transparent plastics material.

One example of an application for the radio relay circuit described would be for tracking goods or vehicles in an urban environment in which the goods or vehicle to be tracked carries a low power radio transmitter. Normally this would be very difficult as the buildings in such an environment prevent the low power radio signals reaching a central receiving station. However by mounting a series of the radio relay circuits described at roof height, or on the side of buildings, it is possible using a steerable laser device at the central station to remotely detect low power radio signals which are being radiated at ground level. Since the local oscillator frequency for each radio relay circuit is provided by the modulation frequency of the interrogating laser device, the radio signals from a number of radio relay circuits can be coherently compared to determine the range of the

transmitter from each relay circuit and from this the position of the radio transmitter determined and tracked. Such an arrangement is particularly useful for tracking the movement of high value shipments, vehicles or stolen vehicles.

A particular advantage of the radio receiver of the present invention is its high performance coupled with its low power consumption and extremely low cost. Since the optical signal provides the local oscillator frequency to the receiver circuit this reduces the power consumption of the circuit, increases the circuit's flexibility and eliminates the need for the circuit to have its own stable reference oscillator.

A further example of an application of the radio relay circuit described is in the construction of a distributed antenna system, such as for example a phased array antenna in which a number of circuits are located in known relationship to one another and interrogated in an appropriate sequence by the laser vibrometer system.

It will be appreciated by those skilled in the art that the circuit will also work for an RF signal 4 which is not modulated (i.e. a continuous wave carrier signal) and the circuit thus operates as a remotely tuneable radio frequency detector. For an unmodulated RF signal 4 the IF signal will also be unmodulated and the reflective surface of the piezoelectric modulator will vibrate at this frequency, thereby modifying and reflecting the optical signal 12. Detection of the modified optical signal 24 is indicative of the presence and magnitude of the radio frequency signal 4.

In addition to functioning as a remotely accessible radio receiver, the circuit can be

configured to further operate as a remotely accessible radio transmitter which is capable of radiating an RF signal with a selected frequency. In such an application the circuit 2 further includes a battery, or a capacitor which is charged from the photo-diode 10 and the FET 14 is configured to self-oscillate and radiate an RF signal from the antenna 8. The FET 14 is configured to self-oscillate using a biasing network (not shown) such that it operates in its relatively higher gain linear region of its gain characteristic. In operation the frequency of self-oscillation of the FET 14 is determined by the modulation frequency of the optical signal 12 which is used to "injection-lock" the frequency of self-oscillation. The circuit can thus act as a remotely tuneable radio transmitter in which the frequency of operation is determined by the modulation frequency of the optical signal 12.

In a preferred embodiment of the invention, as shown in Figure 2, the photodiode 10 is configured to act not only as an optical detector for detecting the optical signal 12 but also to act as the non-linear mixing element 14, thereby eliminating the need for the transistor 14. In this arrangement the antenna comprises a bow-tie dipole broadband patch antenna (though it will be appreciated that other types of antenna can be used) and the photodiode 10 and resonator 16 are connected in parallel across the antenna 8. A radio frequency choke (RFC) 26 is provided between the photodiode 10 and resonator 16 to prevent the radio frequency signal reaching the resonator 16 thereby ensuring that only the IF signal reaches the resonator 16. When the photodiode 10 is illuminated by a sufficiently high intensity optical signal, its behaviour will become non-linear and it can then be used to mix the received RF signal 4 with the local oscillator frequency detected by the photodiode 10. Furthermore in such a circuit it is preferred to mount the photodiode 10 on the surface 22 of the piezoelectric resonator 16, thereby eliminating the

need for the optical beam splitter 18, and this results in an even more compact device.

It will be appreciated by those skilled in the art that the circuit of Figure 2 inherently acts as a remotely tuneable RF transmitter. This is because the photodiode which detects the modulated optical signal 12 generates an RF voltage across the bow-tie dipole antenna 8 which is radiated as an RF signal 38. It is thus possible to operate the circuit as a remotely tuneable radio transmitter by illuminating it with an optical signal which is modulated with the required frequency of transmission of the circuit.

Referring to Figure 3, a further preferred form of the circuit is shown which utilises a loop antenna 28 (though it will be appreciated that the arrangement applies to other types of antenna). In common with the circuit of Figure 2 the photodiode 10 is connected across the open ends of the antenna 28 and performs two functions: (i) it detects the modulation of the optical signal 12 which is applied to the non-linear mixing element 14 via a coupling capacitor 30; and (ii) it acts as a tuning capacitor to set the resonant frequency of the loop antenna 28. The photodiode 10 which is illuminated with the AM optical signal 12 produces a photo current having two components: (a) a high frequency current corresponding to the RF modulation of the optical signal; and (b) a continuous or DC current, resulting from the continuous wave component. The DC current via the loop which comprises a radio frequency choke (RFC) 26 and load resistance 32 controls the DC bias across the photodiode 10 and hence its capacitance. The capacitance of the photodiode (10) is used to tune the antenna 28 to the desired frequency of operation which, for a transmitter circuit, allows efficient radiation of the radio frequency signal 38. The use of a photodiode to both tune an antenna and detect the local oscillator frequency

for a radio frequency circuit is considered to be inventive in its own right.

To further improve the bandwidth of the circuit, two photodiodes 10, 34 are provided, Figure 4. The first photodiode 10 is used to detect the local oscillator frequency and the second photodiode 34 to tune the antenna. In operation this circuit is illuminated with two optical signals, an AM modulated optical signal 12 and a continuous wave (CW) optical signal 36 which is of a different wavelength. As described above, the AM modulated signal 12 determines the local oscillator frequency of the circuit and is detected by the photodiode 10. It will be appreciated that the photodiode 10 can also be used as the non-linear mixing element if the AM modulated optical signal 12 is of sufficient intensity though it is preferred to use a dual gate GaAs FET as the radio frequency mixer. The photodiode 10 preferably includes an optical filter which blocks the CW optical signal 36. The CW optical signal 36 is detected by the second photodiode 34 and is used to control the bias across the antenna 28, thereby allowing the antenna to be tuned for optimum performance.

Referring to Figure 5, there is shown a circuit 44 in accordance with a further aspect of the invention which is for use in a tagging system which uses tags containing "semi-active", "pseudo passive" or "reflective modulating" transponder circuits. As is known a semi-passive transponder is a transceiver circuit which can detect information transmitted to it from an interrogator circuit and transmit information to the interrogator by reflecting and modulating the illuminating signal from the interrogator circuit. As such a semi-passive transponder does not include an active transmitter circuit and relies solely on the interrogator to provide the communication medium.

The circuit 44 of Figure 5 is in essence the same as that illustrated in Figure 2 and comprises a bow-tie dipole patch antenna 8, a radio frequency photodiode 10 connected across the dipole of the antenna and a piezoelectric resonator 16. As will be seen the photodiode 10 is mounted on the reflective surface 22 of the piezoelectric resonator 16 thereby eliminating the need for a beam splitter.

In this implementation the RFC 26 comprises the wire link between the resonator 16 and photodiode 10. The operation of the circuit 44 is substantially the same as that described above, in which the photodiode 10 acts as both the non-linear mixing element and the optical detector. The device 2 is illuminated with an optical signal 12 which is amplitude modulated at the required frequency of transmission of the circuit. The photodiode 10 detects this signal and generates a radio frequency voltage across the antenna 8 which radiates an RF signal 38. This RF signal 38 is received by a semi-passive tag, or transponder circuit 40, which reflectively modulates the RF signal back to the circuit 2. The reflected and modulated signal 42 is received by the interrogator circuit 44 and is mixed in the photodiode 10 with the transmitted frequency to produce an IF signal which corresponds with the modulation signal applied by the tag. The IF signal, which is applied to the piezoelectric crystal via the RFC 26, modifies the phase of the optical signal reflected from it and this modification is coherently de-modulated by the remote optical system 20. The circuit 44 thus acts as an interrogator circuit which is capable of transmitting an RF signal 38 and simultaneously receiving an RF signal 42. A particular advantage of this interrogator circuit 44 over the known arrangements which use radio frequency signals throughout, is that it can be operated at a long range using only low power RF signals.

Whilst in the various embodiments described so far the illuminating signal 12 propagates through free space such that the circuit is an essentially line of sight device it will be appreciated that, in other embodiments, the circuit can be illuminated by guiding the light using an optical fibre or other forms of light guide. One example of such an application is in a cordless telecommunications system for use in a building in which a number of interrogator circuits located at various points around the building are attached to an optical fibre network. A particular advantage of this type of system is that cordless communication is possible using very low power, short range, RF devices.

It will be appreciated that the present invention is not restricted to the specific circuits described and that modifications can be made to them which are within the scope of the invention. For example, whilst the use of a photodiode has been described, other forms of photo-detectors can be used, such as for example, photo-transistor. Furthermore, other forms of non-linear mixing components can be used.

Whilst in all of the embodiments described the circuit can, using the optical signal, remotely detect and receive radio frequency signals it will be appreciated that the circuit can additionally perform further functions such as, for example, using an optical signal to transmit or receive ultrasonic signals. In such an application the incident laser beam is modulated with an ultrasonic AM modulation and the mixer is used to drive the acoustic resonator. Alternatively, the circuit can be operated as an ultrasonic receiver circuit to RF transmit circuit. Here an incident ultrasonic signal generates a voltage from the piezoelectric element which is mixed with a laser-provided local oscillator causing an RF signal to be emitted. In yet a further implementation the radio circuit could be

accessed using a magnetic signal as opposed to an optical signal.

CLAIMS

1. A radio frequency (RF) receiver circuit (2) is characterised by comprising: an antenna (8, 28) for receiving a radio frequency (RF) signal (4); an optical detector (10) for receiving a modulated optical signal (12) and converting it to an electrical signal; means (14) for mixing the electrical and RF signals to produce an intermediate frequency signal; and a reflective optical modulator (16) which is operable at the intermediate frequency to modify and reflect (24) the optical signal (12) with the intermediate frequency.

2. A radio frequency receiver circuit according to Claim 1 and characterised in that the means (14) for mixing comprises a non-linear radio frequency component.

3. A radio frequency receiver circuit according to Claim 2 and characterised in that the non-linear component (14) comprises a transistor.

4. A radio frequency receiver circuit according to any preceding claim and characterised in that the optical receiver (10) comprises a photodiode.

5. A radio frequency receiver circuit according to Claim 4 when dependent on Claim 1 or Claim 2 and characterised in that the non-linear radio frequency component (14) comprises the photodiode (10).

6. A radio frequency receiver circuit according to any preceding claim and

characterised in that the reflective optical modulator (16) comprises a piezoelectric acoustic resonator.

7. A radio frequency receiver circuit according to any preceding claim and further characterised by comprising means (18) for directing a part (12a) of the optical signal (12) onto the optical detector (10) and a part (12b) onto the reflective optical modulator (16).

8. A radio frequency receiver circuit according to any preceding claim and characterised by the optical detector (10) being located on the reflective surface (22) of the reflective optical modulator (16) such that the optical signal (12) is simultaneously incident on both the reflective optical modulator (16) and optical detector (10).

9. A radio frequency receiver circuit according to any preceding claim and further characterised in that the circuit (2) is operable to transmit a radio frequency signal (38) from the antenna (8, 28) and wherein the frequency of said transmitted signal (38) is related to the modulation frequency of the optical signal (12).

10. A radio frequency receiver circuit according to Claim 9 and characterised in that it is capable of simultaneously transmitting (38) and receiving (42) a radio frequency signal.

11. A radio frequency receiver circuit according to any preceding claim and further characterised by a photodiode (34) connected to the antenna (8, 28) such that the resonant

frequency of the antenna (8, 28) can be remotely tuned by using the optical signal (12, 36) to set the capacitance of the photodiode (10, 34).

12. A radio frequency receiver circuit according to Claim 11 in which the photodiode (34) comprises the optical detector (10).

13. An interrogator circuit (44) for use in a tagging system which uses semi-passive transponders (40) and characterised by incorporating a radio frequency receiver circuit (2) according to Claim 10.

14. A radio receiver array characterised by comprising a plurality of radio frequency receiver circuits according to any preceding claim.

15. A distributed antenna system characterised by comprising an optical fibre including a plurality of radio frequency receiver circuits (2), according to any preceding claim, associated with the optical fibre.

16. A radio frequency circuit (2) characterised by comprising: an antenna (8, 28) and photodiode (10) connected across the antenna (8, 28) wherein the photodiode (10) is operable to receive a modulated optical signal (12) to provide the local oscillator frequency of the circuit (2) and wherein the capacitance of the photodiode (10) is used to tune the antenna (8, 28).

Fig.1a.

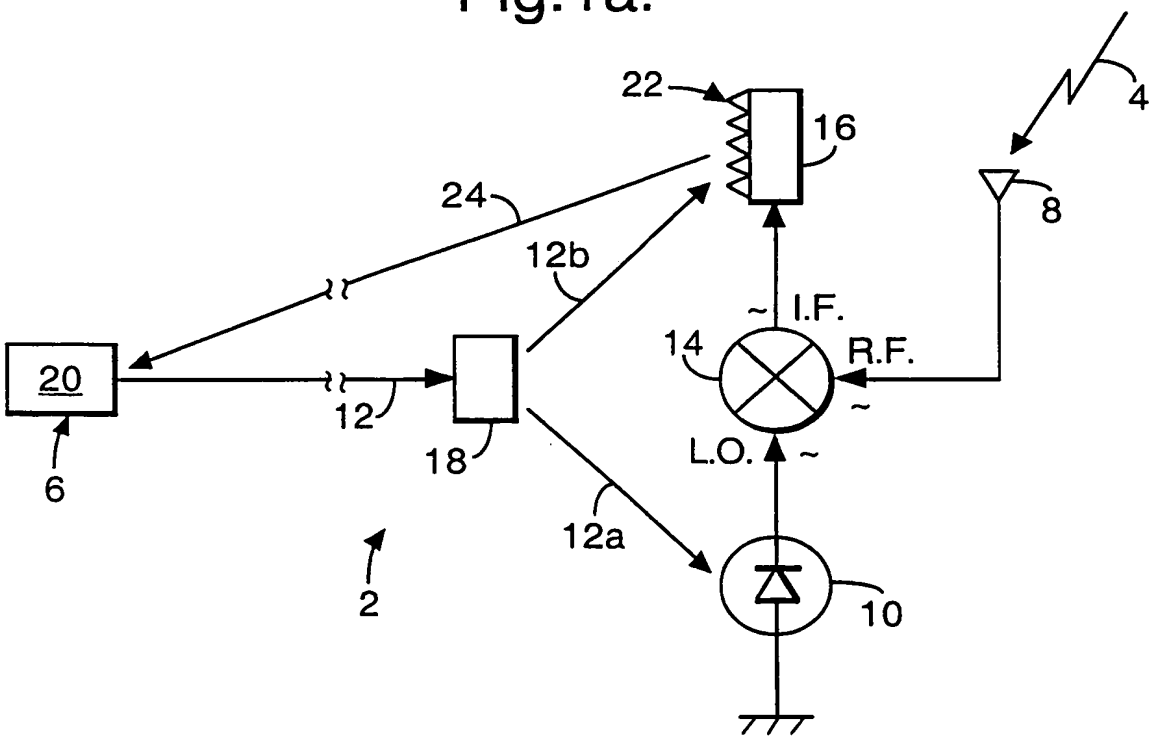
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Fig.1b.

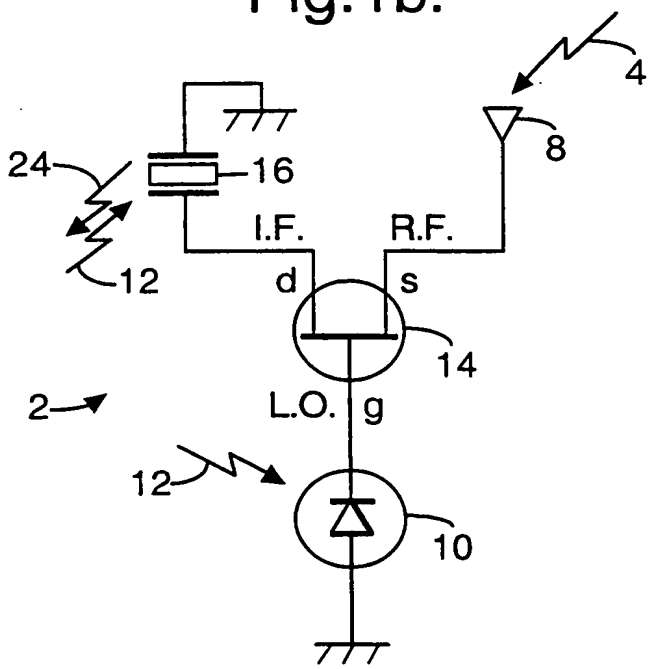
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Fig.2.

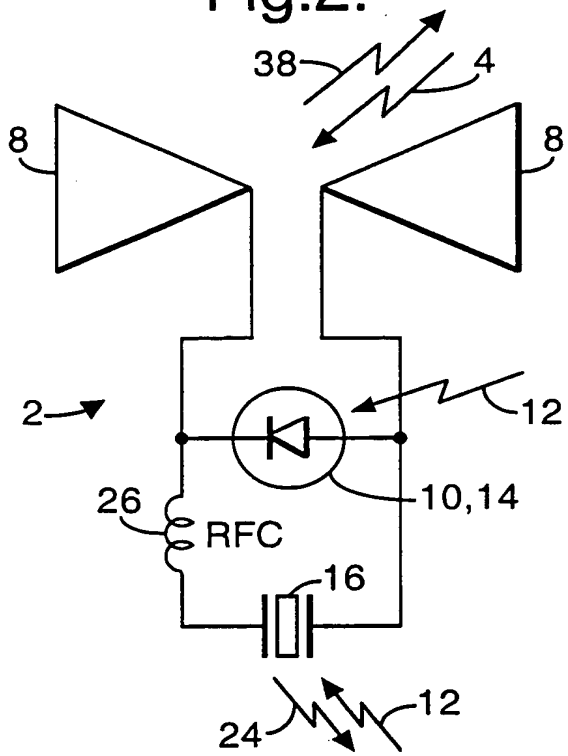
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Fig.3.

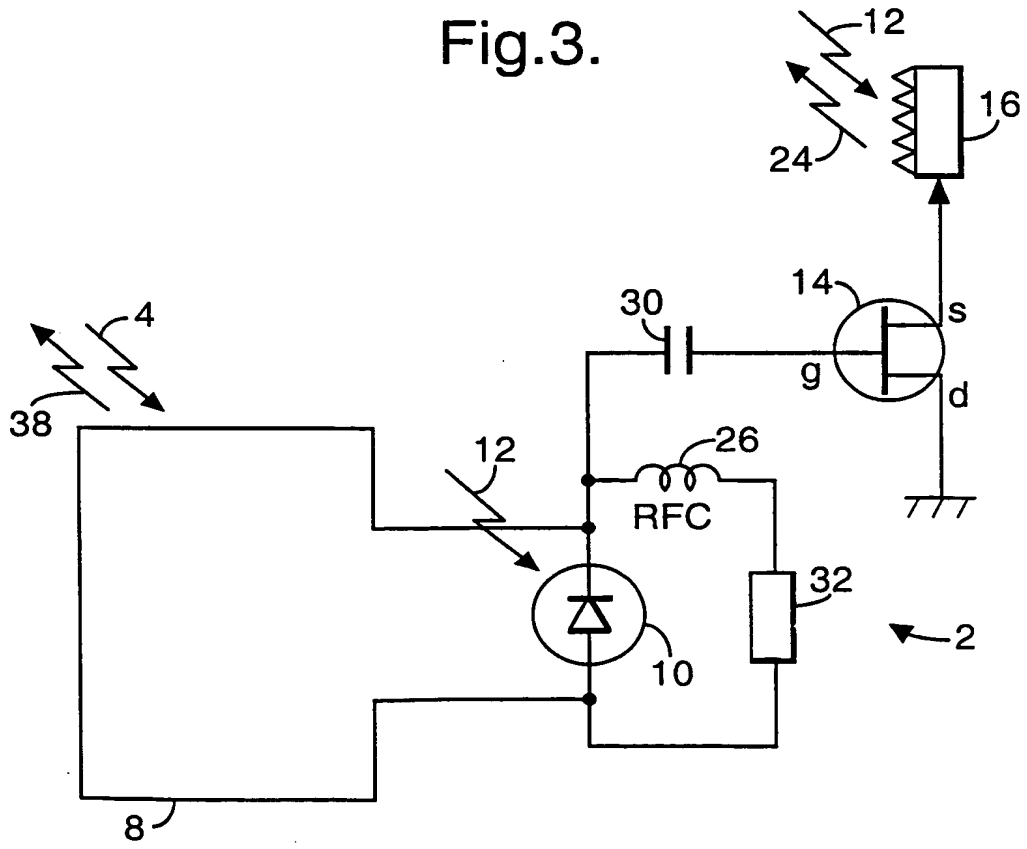
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Fig.4.

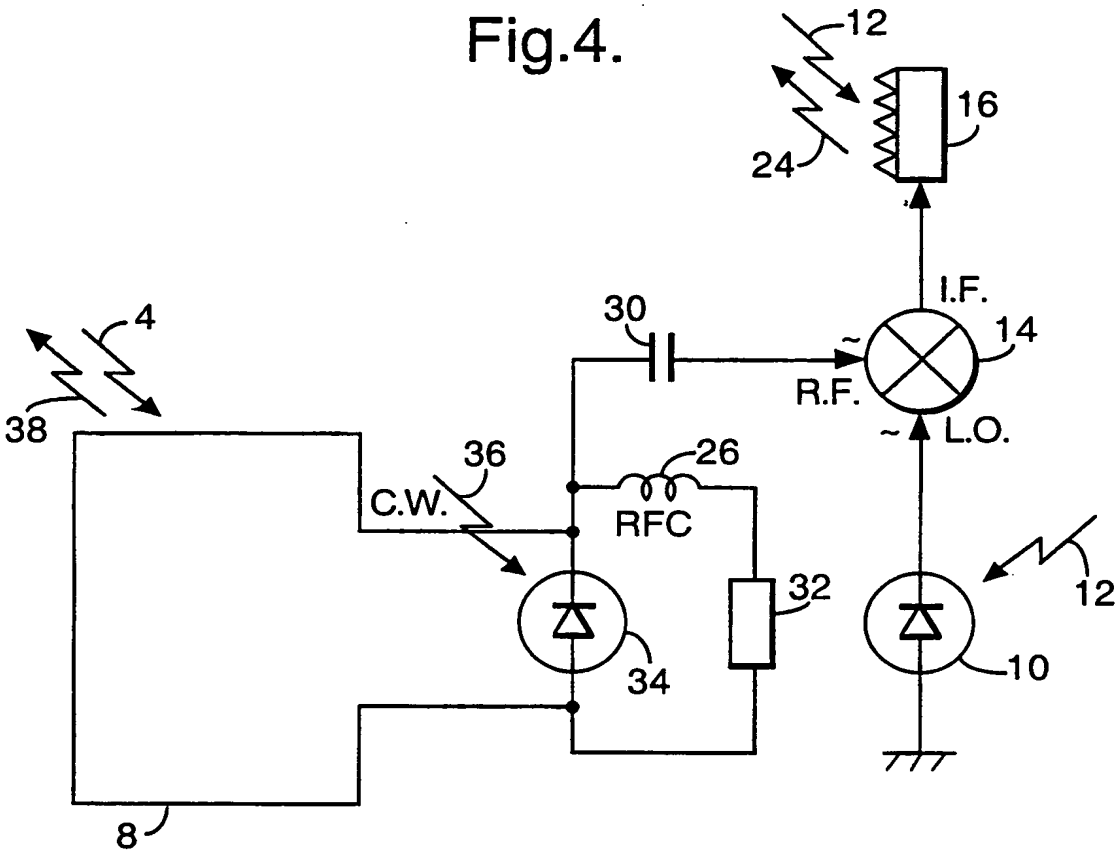
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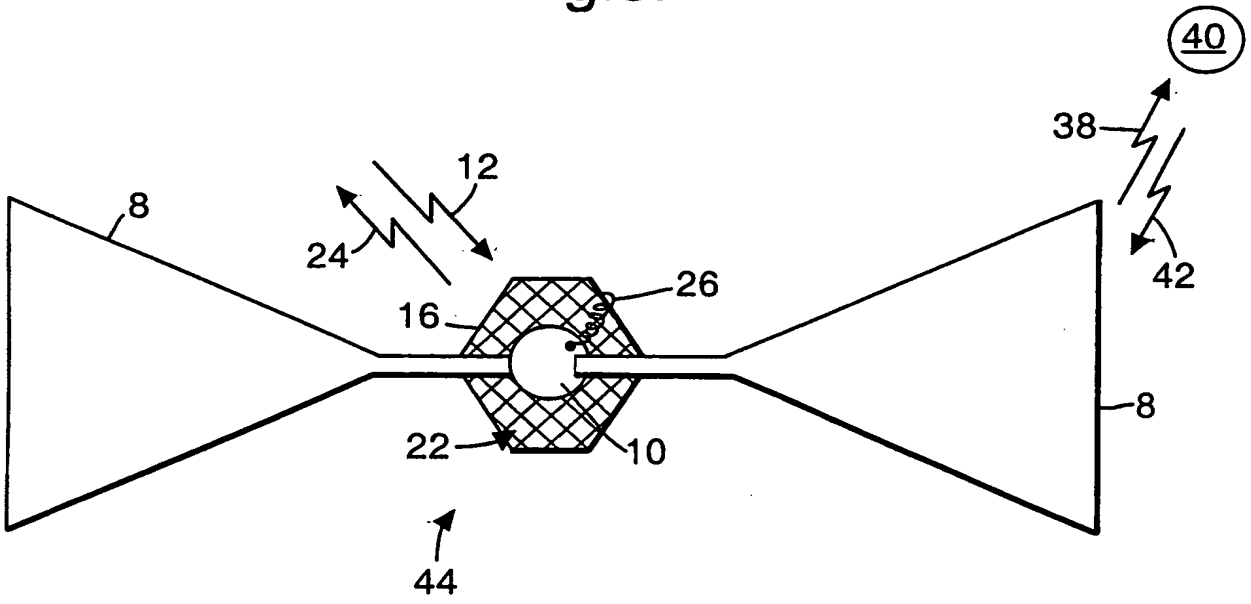
Fig.5.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INTERNATIONAL SEARCH REPORT

Intern .nal Application No
PCT/GB 00/00044

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H04B10/26

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H04B G01S

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5 307 195 A (NICOLE PIERRE) 26 April 1994 (1994-04-26) column 4, line 39 - line 55 column 5, line 7 - line 46 claims 1,3,5; figures 1-3	1,2,9,16
A	US 4 941 205 A (HALE WILLIAM J ET AL) 10 July 1990 (1990-07-10) abstract; figures 1-4	1,4,6-8, 11,12,16
A	PATENT ABSTRACTS OF JAPAN vol. 012, no. 290 (P-742), 9 August 1988 (1988-08-09) & JP 63 065587 A (MATSUSHITA ELECTRIC IND CO LTD), 24 March 1988 (1988-03-24) abstract	1,2,4,6, 9,16

-/--

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
17 March 2000	29/03/2000

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Goudelis, M

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Intern. nal Application No
PCT/GB 00/00044

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	ROSENTHAL D A: "RETROREFLECTING PASSIVE DATA TRANSMITTER" NAVY TECHNICAL DISCLOSURE BULLETIN,US,OFFICE OF NAVAL RESEARCH. ARLINGTON, vol. 10, no. 1, 1 September 1984 (1984-09-01), pages 107-111, XP002069020 page 108, last paragraph -page 109, paragraph 2; figure 1	1,8,11, 16

Form PCT/ISA/210 (continuation of second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Information on patent family members

Intern. ..al Application No
PCT/GB 00/00044

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5307195 A	26-04-1994	FR 2654275 A	10-05-1991
		CA 2028647 A,C	10-05-1991
		DE 69017359 D	06-04-1995
		DE 69017359 T	20-07-1995
		EP 0427586 A	15-05-1991
		ES 2071798 T	01-07-1995
		JP 3192928 A	22-08-1991
		PT 95818 A	31-07-1992
US 4941205 A	10-07-1990	CA 1239665 A	26-07-1988
		EP 0185749 A	02-07-1986
		JP 61502370 T	16-10-1986
		WO 8505530 A	19-12-1985
JP 63065587 A	24-03-1988	NONE	

PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION OF ELECTION

(PCT Rule 61.2)

To:

Assistant Commissioner for Patents
United States Patent and Trademark Office
Box PCT
Washington, D.C.20231
ETATS-UNIS D'AMERIQUE

in its capacity as elected Office

Date of mailing (day/month/year) 06 September 2000 (06.09.00)	
International application No. PCT/GB00/00044	**Applicant's or agent's file reference** P/61460/MRCY
International filing date (day/month/year) 11 January 2000 (11.01.00)	**Priority date** (day/month/year) 16 January 1999 (16.01.99)
Applicant FORSTER, Ian, James	

1. The designated Office is hereby notified of its election made:

[X] in the demand filed with the International Preliminary Examining Authority on:

10 August 2000 (10.08.00)

[ ] in a notice effecting later election filed with the International Bureau on:

2. The election [X] was

[ ] was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

The International Bureau of WIPO **34, chemin des Colombettes** **1211 Geneva 20, Switzerland**	Authorized officer Zakaria EL KHODARY
Facsimile No.: (41-22) 740.14.35	Telephone No.: (41-22) 338.83.38

PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION CONCERNING SUBMISSION OR TRANSMITTAL OF PRIORITY DOCUMENT

(PCT Administrative Instructions, Section 411)

To:

HOSTE, Colin, Francis
Marconi Intellectual Property
Waterhouse Lane
Chelmsford
Essex CM1 2QX
ROYAUME-UNI

6 MAR 2000

Date of mailing (day/month/year) 28 February 2000 (28.02.00)	
Applicant's or agent's file reference P/61460/MRCY	**IMPORTANT NOTIFICATION**
International application No. PCT/GB00/00044	International filing date (day/month/year) 11 January 2000 (11.01.00)
International publication date (day/month/year) Not yet published	Priority date (day/month/year) 16 January 1999 (16.01.99)
Applicant MARCONI CASWELL LIMITED et al	

1. The applicant is hereby notified of the date of receipt (except where the letters "NR" appear in the right-hand column) by the International Bureau of the priority document(s) relating to the earlier application(s) indicated below. Unless otherwise indicated by an asterisk appearing next to a date of receipt, or by the letters "NR", in the right-hand column, the priority document concerned was submitted or transmitted to the International Bureau in compliance with Rule 17.1(a) or (b).

2. This updates and replaces any previously issued notification concerning submission or transmittal of priority documents.

3. An **asterisk(*)** appearing next to a date of receipt, in the right-hand column, denotes a priority document submitted or transmitted to the International Bureau but not in compliance with Rule 17.1(a) or (b). In such a case, **the attention of the applicant is directed** to Rule 17.1(c) which provides that no designated Office may disregard the priority claim concerned before giving the applicant an opportunity, upon entry into the national phase, to furnish the priority document within a time limit which is reasonable under the circumstances.

4. The **letters "NR"** appearing in the right-hand column denote a priority document which was not received by the International Bureau or which the applicant did not request the receiving Office to prepare and transmit to the International Bureau, as provided by Rule 17.1(a) or (b), respectively. In such a case, **the attention of the applicant is directed** to Rule 17.1(c) which provides that no designated Office may disregard the priority claim concerned before giving the applicant an opportunity, upon entry into the national phase, to furnish the priority document within a time limit which is reasonable under the circumstances.

Priority date	Priority application No.	Country or regional Office or PCT receiving Office	Date of receipt of priority document
16 Janu 1999 (16.01.99)	9900901.1	GB	25 Janu 2000 (25.01.00)

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No. (41-22) 740.14.35

Authorized officer

Tessadel PAMPLIEGA

Telephone No. (41-22) 338.83.38

PATENT COOPERATION TREATY

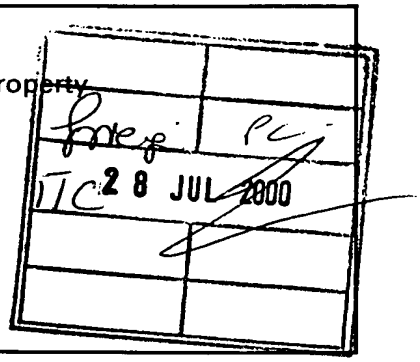
From the INTERNATIONAL BUREAU

PCT

NOTICE INFORMING THE APPLICANT OF THE COMMUNICATION OF THE INTERNATIONAL APPLICATION TO THE DESIGNATED OFFICES

(PCT Rule 47.1(c), first sentence)

To:
HOSTE, Colin, Francis
Marconi Intellectual Property
Waterhouse Lane
Chelmsford
Essex CM1 2QX
ROYAUME-UNI



Date of mailing (day/month/year)	
20 July 2000 (20.07.00)	
Applicant's or agent's file reference P/61460/MRCY	**IMPORTANT NOTICE**
International application No. PCT/GB00/00044	**International filing date** (day/month/year) 11 January 2000 (11.01.00)
Priority date (day/month/year) 16 January 1999 (16.01.99)	
Applicant MARCONI CASWELL LIMITED et al	

1. Notice is hereby given that the International Bureau has communicated, as provided in Article 20, the international application to the following designated Offices on the date indicated above as the date of mailing of this Notice:
   AU,CN,JP,KP,KR,US

   In accordance with Rule 47.1(c), third sentence, those Offices will accept the present Notice as conclusive evidence that the communication of the international application has duly taken place on the date of mailing indicated above and no copy of the international application is required to be furnished by the applicant to the designated Office(s).

2. The following designated Offices have waived the requirement for such a communication at this time:
   AE,AL,AM,AP,AT,AZ,BA,BB,BG,BR,BY,CA,CH,CR,CU,CZ,DE,DK,DM,EA,EE,EP,ES,FI,GB,GD,GE,
   GH,GM,HR,HU,ID,IL,IN,IS,KE,KG,KZ,LC,LK,LR,LS,LT,LU,LV,MA,MD,MG,MK,MN,MW,MX,NO,NZ,
   OA,PL,PT,RO,RU,SD,SE,SG,SI,SK,SL,TJ,TM,TR,TT,TZ,UA,UG,UZ,VN,YU,ZA,ZW
   The communication will be made to those Offices only upon their request. Furthermore, those Offices do not require the applicant to furnish a copy of the international application (Rule 49.1(a-bis)).

3. Enclosed with this Notice is a copy of the international application as published by the International Bureau on
   20 July 2000 (20.07.00) under No. WO 00/42721

REMINDER REGARDING CHAPTER II (Article 31(2)(a) and Rule 54.2)

If the applicant wishes to postpone entry into the national phase until 30 months (or later in some Offices) from the priority date, **a demand for international preliminary examination** must be filed with the competent International Preliminary Examining Authority before the expiration of 19 months from the priority date.

It is the applicant's sole responsibility to monitor the 19-month time limit.

Note that only an applicant who is a national or resident of a PCT Contracting State which is bound by Chapter II has the right to file a demand for international preliminary examination.

REMINDER REGARDING ENTRY INTO THE NATIONAL PHASE (Article 22 or 39(1))

If the applicant wishes to proceed with the international application in the **national phase**, he must, within 20 months or 30 months, or later in some Offices, perform the acts referred to therein before each designated or elected Office.

For further important information on the time limits and acts to be performed for entering the national phase, see the Annex to Form PCT/IB/301 (Notification of Receipt of Record Copy) and Volume II of the PCT Applicant's Guide.

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No. (41-22) 740.14.35

Authorized officer
J. Zahra

Telephone No. (41-22) 338.83.38

PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

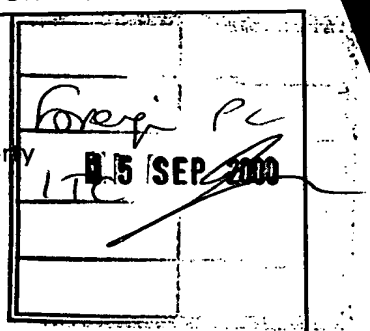
PCT

INFORMATION CONCERNING ELECTED OFFICES NOTIFIED OF THEIR ELECTION

(PCT Rule 61.3)

To:

HOSTE, Colin, Francis
Marconi Intellectual Property
Waterhouse Lane
Chelmsford
Essex CM1 2QX
ROYAUME-UNI



Date of mailing (day/month/year)	
06 September 2000 (06.09.00)	
Applicant's or agent's file reference P/61460/MRCY	**IMPORTANT INFORMATION**
International application No. PCT/GB00/00044	**International filing date** (day/month/year) 11 January 2000 (11.01.00)
Priority date (day/month/year) 16 January 1999 (16.01.99)	
Applicant MARCONI CASWELL LIMITED et al	

1. The applicant is hereby informed that the International Bureau has, according to Article 31(7), notified each of the following Offices of its election:

   AP :GH,GM,KE,LS,MW,SD,SL,SZ,TZ,UG,ZW
   EP :AT,BE,CH,CY,DE,DK,ES,FI,FR,GB,GR,IE,IT,LU,MC,NL,PT,SE
   National :AU,BG,BR,CA,CN,CZ,DE,IL,JP,KP,KR,MN,NO,NZ,PL,RO,RU,SE,SK,US

2. The following Offices have waived the requirement for the notification of their election; the notification will be sent to them by the International Bureau only upon their request:

   EA :AM,AZ,BY,KG,KZ,MD,RU,TJ,TM
   OA :BF,BJ,CF,CG,CI,CM,GA,GN,GW,ML,MR,NE,SN,TD,TG
   National :AE,AL,AM,AT,AZ,BA,BB,BY,CH,CR,CU,DK,DM,EE,ES,FI,GB,GD,GE,GH,GM, HR,HU,ID,IN,IS,KE,KG,KZ,LC,LK,LR,LS,LT,LU,LV,MA,MD,MG,MK,MW,MX,PT,SD,SG, SI,SL,TJ,TM,TR,TT,TZ,UA,UG,UZ,VN,YU,ZA,ZW

   pinkslip already issued. SMB

3. The applicant is reminded that he must enter the "national phase" **before the expiration of 30 months from the priority date** before each of the Offices listed above. This must be done by paying the national fee(s) and furnishing , if prescribed, a translation of the international application (Article 39(1)(a)), as well as, where applicable, by furnishing a translation of any annexes of the international preliminary examination report (Article 36(3)(b) and Rule 74.1).

   Some offices have fixed time limits expiring later than the above-mentioned time limit. For detailed information about the applicable time limits and the acts to be performed upon entry into the national phase before a particular Office, see Volume II of the PCT Applicant's Guide.

   The entry into the European regional phase is postponed **until 31 months from the priority date** for all States designated for the purposes of obtaining a European patent.

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No. (41-22) 740.14.35

Authorized officer:

Zakaria EL KHODARY

Telephone No. (41-22) 338.83.38

PATENT COOPERATION TREATY

From the:
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

To:
Hoste,Colin Francis
MARCONI INTELLECTUAL PROPERTY ITC
Waterhouse Lane
Chelmsford, Essex CM1 2QX
GRANDE BRETAGNE

18 SEP 2000

PCT

WRITTEN OPINION

(PCT Rule 66)

Date of mailing *(day/month/year)*	13.09.2000
Applicant's or agent's file reference: P/61460/MRCY	**REPLY DUE** **within 3 month(s)** from the above date of mailing

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/GB00/00044	11/01/2000	16/01/1999

International Patent Classification (IPC) or both national classification and IPC
H04B10/26

Applicant
Marconi Caswell Limited et al

1. This written opinion is the **first** drawn up by this International Preliminary Examining Authority.

2. This opinion contains indications relating to the following items:

I	☒	Basis of the opinion
II	☐	Priority
III	☐	Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
IV	☐	Lack of unity of invention
V	☐	Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
VI	☐	Certain document cited
VII	☒	Certain defects in the international application
VIII	☒	Certain observations on the international application

3. The applicant is hereby **invited to reply** to this opinion.

When? See the time limit indicated above. The applicant may, before the expiration of that time limit, request this Authority to grant an extension, see Rule 66.2(d).

How? By submitting a written reply, accompanied, where appropriate, by amendments, according to Rule 66.3. For the form and the language of the amendments, see Rules 66.8 and 66.9.

Also: For an additional opportunity to submit amendments, see Rule 66.4.
For the examiner's obligation to consider amendments and/or arguments, see Rule 66.4 bis.
For an informal communication with the examiner, see Rule 66.6.

If no reply is filed, the international preliminary examination report will be established on the basis of this opinion.

4. The final date by which the international preliminary examination report must be established according to Rule 69.2 is: 16/05/2001.

Name and mailing address of the international preliminary examining authority:
European Patent Office - P.B. 5818 Patentlaan 2
NL-2280 HV Rijswijk - Pays Bas
Tel. +31 70 340 - 2040 Tx: 31 651 epo nl
Fax: +31 70 340 - 3016

Authorized officer / Examiner
Goudelis, M

Formalities officer (incl. extension of time limits)
Smits, A
Telephone No. +31 70 340 3596

I. Basis of the opinion

1. This opinion has been drawn on the basis of (*substitute sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this opinion as "originally filed".*):

Description, pages:

1-14 as originally filed

Claims, No.:

1-16 as originally filed

Drawings, sheets:

1/5-5/5 as originally filed

2. The amendments have resulted in the cancellation of:

☐ the description, pages:
☐ the claims, Nos.:
☐ the drawings, sheets:

3. This opinion has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

4. Additional observations, if necessary:

VII. Certain defects in the international application

The following defects in the form or contents of the international application have been noted:

see separate sheet

VIII. Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:

see separate sheet

Re Item VII
Certain defects in the international application

1. Reference is made to the following document :

   D1 = US-A-5307195 (NICOLE)

2. Although all claims meet the criteria set forth in Article 33(1) PCT with respect to the available prior art, amendment appears to be necessary to overcome the objections of sections VII and VIII.

3. To meet the requirements of Rule 5.1(a)(ii) PCT, the document D1 should be identified in the description and the relevant background art disclosed therein should be briefly discussed.

4. To meet the requirements of Rule 6.3(b) PCT the independent claims 1 and 16 should be properly cast in the two-part form, with those features which in combination are part of the prior art (see document D1) being placed in the preamble.

Re Item VIII
Certain observations on the international application

1. The general statement in the description at page 13, lines 10-12, is not clear and when used to interpret the claims renders them also unclear, contrary to Article 6 PCT. The statement should therefore be deleted.

2. In figure 3, reference 8 should probably be replaced by 28 in order to correspond to the description.

PATENT COOPERATION TREATY

14

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference	FOR FURTHER ACTION	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
P/61460/MRCY		
International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/GB00/00044	11/01/2000	16/01/1999
International Patent Classification (IPC) or national classification and IPC H04B10/26		
Applicant Marconi Caswell Limited et al		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 4 sheets, including this cover sheet.

   ☒ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 5 sheets.

3. This report contains indications relating to the following items:

   - I ☒ Basis of the report
   - II ☐ Priority
   - III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   - IV ☐ Lack of unity of invention
   - V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations suporting such statement
   - VI ☐ Certain documents cited
   - VII ☐ Certain defects in the international application
   - VIII ☐ Certain observations on the international application

Date of submission of the demand	Date of completion of this report
10/08/2000	09. 03. 2001
Name and mailing address of the international preliminary examining authority: European Patent Office - P.B. 5818 Patentlaan 2 NL-2280 HV Rijswijk - Pays Bas Tel. +31 70 340 - 2040 Tx: 31 651 epo nl Fax: +31 70 340 - 3016	Authorized officer Goudelis, M Telephone No. +31 70 340 2919

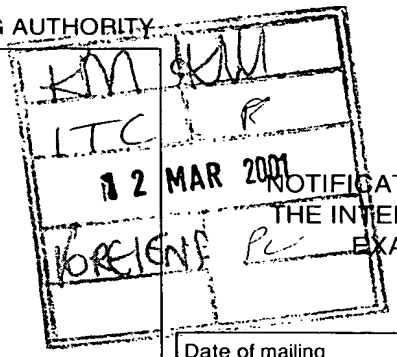
Form PCT/IPEA/409 (cover sheet) (January 1994)

PATENT COOPERATION TREATY

From the
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

To:

Hoste,Colin Francis
MARCONI INTELLECTUAL PROPERTY
Waterhouse Lane
Chelmsford, Essex CM1 2QX
GRANDE BRETAGNE



PCT

NOTIFICATION OF TRANSMITTAL OF THE INTERNATIONAL PRELIMINARY EXAMINATION REPORT
(PCT Rule 71.1)

	Date of mailing *(day/month/year)* 09. 03. 2001
Applicant's or agent's file reference P/61460/MRCY	**IMPORTANT NOTIFICATION**

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/GB00/00044	11/01/2000	16/01/1999

Applicant
Marconi Caswell Limited et al

1. The applicant is hereby notified that this International Preliminary Examining Authority transmits herewith the international preliminary examination report and its annexes, if any, established on the international application.

2. A copy of the report and its annexes, if any, is being transmitted to the International Bureau for communication to all the elected Offices.

3. Where required by any of the elected Offices, the International Bureau will prepare an English translation of the report (but not of any annexes) and will transmit such translation to those Offices.

4. **REMINDER**

The applicant must enter the national phase before each elected Office by performing certain acts (filing translations and paying national fees) within 30 months from the priority date (or later in some Offices) (Article 39(1)) (see also the reminder sent by the International Bureau with Form PCT/IB/301).

Where a translation of the international application must be furnished to an elected Office, that translation must contain a translation of any annexes to the international preliminary examination report. It is the applicant's responsibility to prepare and furnish such translation directly to each elected Office concerned.

For further details on the applicable time limits and requirements of the elected Offices, see Volume II of the PCT Applicant's Guide.

Name and mailing address of the IPEA/	Authorized officer
European Patent Office - P.B. 5818 Patentlaan 2 NL-2280 HV Rijswijk - Pays Bas Tel. +31 70 340 - 2040 Tx: 31 651 epo nl Fax: +31 70 340 - 3016	Smits, A Tel.+31 70 340-3596

Form PCT/IPEA/416 (July 1992)

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference	FOR FURTHER ACTION	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
P/61460/MRCY		
International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/GB00/00044	11/01/2000	16/01/1999
International Patent Classification (IPC) or national classification and IPC H04B10/26		
Applicant Marconi Caswell Limited et al		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 4 sheets, including this cover sheet.

   ☒ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 1 sheets.

3. This report contains indications relating to the following items:

   - I ☒ Basis of the report
   - II ☐ Priority
   - III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   - IV ☐ Lack of unity of invention
   - V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations suporting such statement
   - VI ☐ Certain documents cited
   - VII ☐ Certain defects in the international application
   - VIII ☐ Certain observations on the international application

Date of submission of the demand	Date of completion of this report
10/08/2000	09. 03. 2001
Name and mailing address of the international preliminary examining authority: European Patent Office - P.B. 5818 Patentlaan 2 NL-2280 HV Rijswijk - Pays Bas Tel. +31 70 340 - 2040 Tx: 31 651 epo nl Fax: +31 70 340 - 3016	Authorized officer Goudelis, M Telephone No. +31 70 340 2919

Form PCT/IPEA/409 (cover sheet) (January 1994)

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/GB00/00044

I. Basis of the report

1. This report has been drawn on the basis of *(substitute sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to the report since they do not contain amendments (Rules 70.16 and 70.17).)*:
Description, pages:

2,3,5-14	as originally filed			
1,1a,4	as received on	24/01/2001	with letter of	19/01/2001

Claims, No.:

6 (part),7-10, 11 (part)	as originally filed			
1-5,6 (part),11 (part), 12-16	as received on	24/01/2001	with letter of	19/01/2001

Drawings, sheets:

1/5-5/5	as originally filed

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

   These elements were available or furnished to this Authority in the following language: , which is:

   - ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
   - ☐ the language of publication of the international application (under Rule 48.3(b)).
   - ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

   - ☐ contained in the international application in written form.
   - ☐ filed together with the international application in computer readable form.
   - ☐ furnished subsequently to this Authority in written form.
   - ☐ furnished subsequently to this Authority in computer readable form.
   - ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
   - ☐ The statement that the information recorded in computer readable form is identical to the written sequence

listing has been furnished.

4. The amendments have resulted in the cancellation of:

   ☐ the description, pages:
   ☐ the claims, Nos.:
   ☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

   (Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	1-16
	No:	Claims	
Inventive step (IS)	Yes:	Claims	1-16
	No:	Claims	
Industrial applicability (IA)	Yes:	Claims	1-16
	No:	Claims	

2. Citations and explanations
   see separate sheet

Re Item V

Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

The invention concerns a radio frequency receiver circuit (claim 1) and a radio frequency circuit (claim 16) comprising an antenna for receiving a radio frequency signal.

Such radio frequency circuits are known from D1 = US-A-5307195 (NICOLE), cited in page 1 of the description.

In order to make such a receiver circuit simple and inexpensive but yet providing a high performance capability, the circuit comprises an optical detector which receives a modulated optical signal and converts it into an electrical signal, mixing the electrical and radio frequency signals in order to produce an intermediate frequency signal. The circuit does not then have to use a local oscillator, since this function is done by the modulation frequency of the optical signal. The circuit consequently does not need to generate its own stable reference frequency and this reduces the circuit's complexity, electrical power consumption and cost.

Such a radio frequency circuit and a radio frequency receiver circuit are not obvious from the prior art and consequently the subject matter of claims 1 and 16 is new and inventive.

The subject matter of claims 2-12, dependent of claim 1 is consequently also new and inventive. The interrogator circuit of claim 13, the radio receiver array of claim 14 and the distributed antenna system of claim 15 are all characterized by comprising the radio frequency receiver circuit according to the claims 1-12 and are consequently also new and inventive.

The amendments in the description are introduced in order to acknowledge the prior art and do not introduce subject matter extending beyond the content of the application as filed and therefore do not offend Article 19(2) PCT.

The amendments in the claims 1 and 16 are introduced in order to properly cast them in the two-part form according to Rule 6.3(b)PCT.

RADIO FREQUENCY RECEIVER CIRCUIT

This invention relates to a radio frequency (RF) receiver circuit and more especially, although not exclusively, to a remotely accessible and tuneable radio receiver circuit for use as a radio relay.

According to the present invention a radio frequency receiver circuit is characterised by comprising: an antenna for receiving a radio frequency signal; an optical detector for receiving a modulated optical signal and converting it to an electrical signal; means for mixing the electrical and radio frequency signals to produce an intermediate frequency signal; and a reflective optical modulator which is operable at the intermediate frequency to modify and reflect the optical signal with the intermediate frequency signal.

By detecting the optical signal which has been modified and reflected by the circuit, it is possible to remotely detect the radio frequency (RF) signal received by the circuit and the circuit thus acts as a remotely accessible RF receiver. Furthermore, since the modulation frequency of the illuminating optical signal determines the local oscillator frequency of the circuit, the circuit further operates as a remotely tuneable RF receiver. The term radio frequency is intended to have a broad meaning to include any electromagnetic radiation which is propagating in free space and is intended to include such radiation in at least the frequency range 10 kHz to 300GHz. A particular advantage of the receiver circuit of the present invention is that due to its simplicity it is inexpensive and yet provides a high performance capability. Depending on the performance required the circuit can either include its own power source such as a battery or it can rely on the

space and thus the circuit operates as an essentially 'line of sight' device or can be guided using an optical fibre or other light guide. In the latter case and in accordance with a further application of the invention, a distributed antenna system comprises one or more optical fibres including a plurality of radio frequency receiver circuits described above, associated with the optical fibre/s. Such an arrangement finds particular application as part of a telecommunications system within a building as it enables cordless communication using low power radio devices.

According to a second aspect of the invention a radio frequency circuit is characterised by comprising an antenna and a photodiode connected across the antenna wherein the photodiode is operable to receive a modulated optical signal to provide the local oscillator frequency of the circuit and wherein the capacitance of the photodiode is used to tune the antenna.

In order that the invention may be better understood, five circuits in accordance with of the invention will now be described, by way of example only, with reference to the accompanying drawings in which:

Figure 1a is a schematic representation of a radio frequency receiver (relay) circuit in accordance with the invention;

Figure 1b is a schematic circuit diagram of the relay circuit of Figure 1a;

Figure 2 is a schematic of a further remotely accessible radio frequency relay circuit in

CLAIMS

1. A radio frequency (RF) receiver circuit (2) is characterised by comprising: an antenna (8, 28) for receiving a radio frequency (RF) signal (4); an optical detector (10) for receiving a modulated optical signal (12) and converting it to an electrical signal; means (14) for mixing the electrical and RF signals to produce an intermediate frequency signal; and a reflective optical modulator (16) which is operable at the intermediate frequency to modify and reflect (24) the optical signal (12) with the intermediate frequency.

2. A radio frequency receiver circuit according to Claim 1 and characterised in that the means (14) for mixing comprises a non-linear radio frequency component.

3. A radio frequency receiver circuit according to Claim 2 and characterised in that the non-linear component (14) comprises a transistor.

4. A radio frequency receiver circuit according to any preceding claim and characterised in that the optical receiver (10) comprises a photodiode.

5. A radio frequency receiver circuit according to Claim 4 when dependent on Claim 1 or Claim 2 and characterised in that the non-linear radio frequency component (14) comprises the photodiode (10).

6. A radio frequency receiver circuit according to any preceding claim and

frequency of the antenna (8, 28) can be remotely tuned by using the optical signal (12, 36) to set the capacitance of the photodiode (10, 34).

12. A radio frequency receiver circuit according to Claim 11 in which the photodiode (34) comprises the optical detector (10).

13. An interrogator circuit (44) for use in a tagging system which uses semi-passive transponders (40) and characterised by incorporating a radio frequency receiver circuit (2) according to Claim 10.

14. A radio receiver array characterised by comprising a plurality of radio frequency receiver circuits according to any preceding claim.

15. A distributed antenna system characterised by comprising an optical fibre including a plurality of radio frequency receiver circuits (2), according to any preceding claim, associated with the optical fibre.

16. A radio frequency circuit (2) characterised by comprising: an antenna (8, 28) and photodiode (10) connected across the antenna (8, 28) wherein the photodiode (10) is operable to receive a modulated optical signal (12) to provide the local oscillator frequency of the circuit (2) and wherein the capacitance of the photodiode (10) is used to tune the antenna (8, 28).

PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

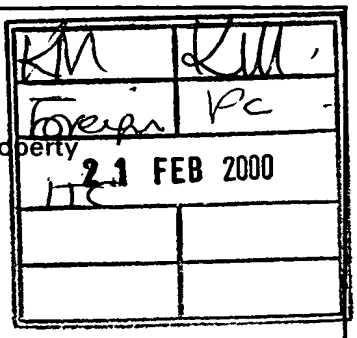
PCT

NOTIFICATION OF RECEIPT OF RECORD COPY

(PCT Rule 24.2(a))

To:

HOSTE, Colin, Francis
Marconi Intellectual Property
Waterhouse Lane
Chelmsford
Essex CM1 2QX
ROYAUME-UNI



Date of mailing (day/month/year)	IMPORTANT NOTIFICATION
10 February 2000 (10.02.00)	
Applicant's or agent's file reference	**International application No.**
P/61460/MRCY	PCT/GB00/00044

The applicant is hereby notified that the International Bureau has received the record copy of the international application as detailed below.

Name(s) of the applicant(s) and State(s) for which they are applicants:

MARCONI CASWELL LIMITED (for all designated States except US)
FORSTER, Ian, James (for US)

International filing date	:	11 January 2000 (11.01.00)
Priority date(s) claimed	:	16 January 1999 (16.01.99)
Date of receipt of the record copy by the International Bureau	:	26 January 2000 (26.01.00)
List of designated Offices	:	

AP :GH,GM,KE,LS,MW,SD,SL,SZ,TZ,UG,ZW
EA :AM,AZ,BY,KG,KZ,MD,RU,TJ,TM
EP :AT,BE,CH,CY,DE,DK,ES,FI,FR,GB,GR,IE,IT,LU,MC,NL,PT,SE
OA :BF,BJ,CF,CG,CI,CM,GA,GN,GW,ML,MR,NE,SN,TD,TG
National :AE,AL,AM,AT,AU,AZ,BA,BB,BG,BR,BY,CA,CH,CN,CR,CU,CZ,DE,DK,DM,EE,ES,FI,GB,GD,GE,GH,GM,HR,HU,ID,IL,IN,IS,JP,KE,KG,KP,KR,KZ,LC,LK,LR,LS,LT,LU,LV,MA,MD,MG,MK,MN,MW,MX,NO,NZ,PL,PT,RO,RU,SD,SE,SG,SI,SK,SL,TJ,TM,TR,TT,TZ,UA,UG,US,UZ,VN,YU,ZA,ZW

ATTENTION

The applicant should carefully check the data appearing in this Notification. In case of any discrepancy between these data and the indications in the international application, the applicant should immediately inform the International Bureau.

In addition, the applicant's attention is drawn to the information contained in the Annex, relating to:

- [X] time limits for entry into the national phase
- [ ] confirmation of precautionary designations
- [X] requirements regarding priority documents

A copy of this Notification is being sent to the receiving Office and to the International Searching Authority.

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No. (41-22) 740.14.35

Authorized officer:

F. Gateau

Telephone No. (41-22) 338.83.38

INFORMATION ON TIME LIMITS FOR ENTERING THE NATIONAL PHASE

The applicant is reminded that the "national phase" must be entered before each of the designated Offices indicated in the Notification of Receipt of Record Copy (Form PCT/IB/301) by paying national fees and furnishing translations, as prescribed by the applicable national laws.

The time limit for performing these procedural acts is **20 MONTHS** from the priority date or, for those designated States which the applicant elects in a demand for international preliminary examination or in a later election, **30 MONTHS** from the priority date, provided that the election is made before the expiration of 19 months from the priority date. Some designated (or elected) Offices have fixed time limits which expire even later than 20 or 30 months from the priority date. In other Offices an extension of time or grace period, in some cases upon payment of an additional fee, is available.

In addition to these procedural acts, the applicant may also have to comply with other special requirements applicable in certain Offices. **It is the applicant's responsibility** to ensure that the necessary steps to enter the national phase are taken in a timely fashion. Most designated Offices do not issue reminders to applicants in connection with the entry into the national phase.

For detailed information about the procedural acts to be performed to enter the national phase before each designated Office, the applicable time limits and possible extensions of time or grace periods, and any other requirements, see the relevant Chapters of Volume II of the PCT Applicant's Guide. Information about the requirements for filing a demand for international preliminary examination is set out in Chapter IX of Volume I of the PCT Applicant's Guide.

GR and ES became bound by PCT Chapter II on 7 September 1996 and 6 September 1997, respectively, and may, therefore, be elected in a demand or a later election filed on or after 7 September 1996 and 6 September 1997, respectively, regardless of the filing date of the international application. (See second paragraph above.)

Note that only an applicant who is a national or resident of a PCT Contracting State which is bound by Chapter II has the right to file a demand for international preliminary examination.

CONFIRMATION OF PRECAUTIONARY DESIGNATIONS

This notification lists only specific designations made under Rule 4.9(a) in the request. It is important to check that these designations are correct. Errors in designations can be corrected where precautionary designations have been made under Rule 4.9(b). The applicant is hereby reminded that any precautionary designations may be confirmed according to Rule 4.9(c) before the expiration of 15 months from the priority date. If it is not confirmed, it will automatically be regarded as withdrawn by the applicant. There will be no reminder and no invitation. Confirmation of a designation consists of the filing of a notice specifying the designated State concerned (with an indication of the kind of protection or treatment desired) and the payment of the designation and confirmation fees. Confirmation must reach the receiving Office within the 15-month time limit.

REQUIREMENTS REGARDING PRIORITY DOCUMENTS

For applicants who have not yet complied with the requirements regarding priority documents, the following is recalled.

Where the priority of an earlier national, regional or international application is claimed, the applicant must submit a copy of the said earlier application, certified by the authority with which it was filed ("the priority document") to the receiving Office (which will transmit it to the International Bureau) or directly to the International Bureau, before the expiration of 16 months from the priority date, provided that any such priority document may still be submitted to the International Bureau before that date of international publication of the international application, in which case that document will be considered to have been received by the International Bureau on the last day of the 16-month time limit (Rule 17.1(a)).

Where the priority document is issued by the receiving Office, the applicant may, instead of submitting the priority document, request the receiving Office to prepare and transmit the priority document to the International Bureau. Such request must be made before the expiration of the 16-month time limit and may be subjected by the receiving Office to the payment of a fee (Rule 17.1(b)).

If the priority document concerned is not submitted to the International Bureau or if the request to the receiving Office to prepare and transmit the priority document has not been made (and the corresponding fee, if any, paid) within the applicable time limit indicated under the preceding paragraphs, any designated State may disregard the priority claim, provided that no designated Office may disregard the priority claim concerned before giving the applicant an opportunity to furnish the priority document within a time limit which is reasonable under the circumstances.

Where several priorities are claimed, the priority date to be considered for the purposes of computing the 16-month time limit is the filing date of the earliest application whose priority is claimed.

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference	FOR FURTHER ACTION	see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.
P/61460/MRCY		
International application No.	International filing date *(day/month/year)*	(Earliest) Priority Date *(day/month/year)*
PCT/GB 00/ 00044	11/01/2000	16/01/1999
Applicant		
Marconi Caswell Limited et al		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 3 sheets.

[X] It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**

   a. With regard to the **language**, the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

   [ ] the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

   b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing :

   [ ] contained in the international application in written form.

   [ ] filed together with the international application in computer readable form.

   [ ] furnished subsequently to this Authority in written form.

   [ ] furnished subsequently to this Authority in computer readbie form.

   [ ] the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

   [ ] the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

2. [ ] **Certain claims were found unsearchable** (See Box I).

3. [ ] **Unity of invention is lacking** (see Box II).

4. With regard to the **title**,

   [X] the text is approved as submitted by the applicant.

   [ ] the text has been established by this Authority to read as follows:

5. With regard to the **abstract**,

   [X] the text is approved as submitted by the applicant.

   [ ] the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is Figure No. 1A

   [X] as suggested by the applicant.

   [ ] because the applicant failed to suggest a figure.

   [ ] because this figure better characterizes the invention.

   [ ] None of the figures.